PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : B63H 20/12, 21/17, 25/42 — A1

(11) International Publication Number: WO 00/37308

(43) International Publication Date: 29 June 2000 (29.06.00)

(21) International Application Number: PCT/FI99/01061

(22) International Filing Date: 21 December 1999 (21.12.99)

(30) Priority Data:
982774 22 December 1998 (22.12.98) FI

(71) Applicant *(for all designated States except US)*: KAMEWA FINLAND OY [FI/FI]; Suojantie 5, FIN-26100 Rauma (FI).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: HEINISUO, Tapio [FI/FI]; Siikavahe 2 C 18, FIN-26100 Rauma (FI).

(74) Agent: FORSSÉN & SALOMAA OY; Yrjönkatu 30, FIN-00100 Helsinki (FI).

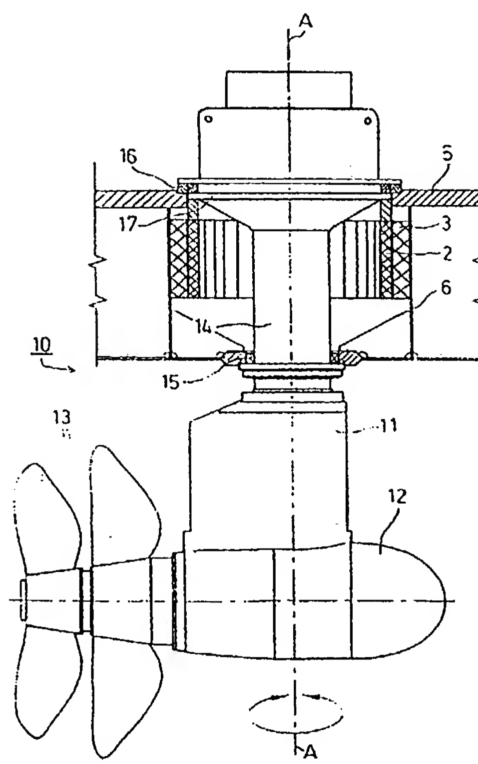
(81) Designated States: CA, NO, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.
In English translation (filed in Finnish).

(54) Title: TURNABLE PROPELLER DEVICE FOR A SHIP, AN OFFSHORE STRUCTURE OR EQUIVALENT

(57) Abstract

The invention relates to a turnable propeller device for a ship, an offshore structure or equivalent. The propeller device comprises a vertical frame (11) which is mounted by means of bearings on a frame (5) of the propeller device, ship or equivalent so as to be turnable with respect to a substantially vertical axis of rotation (A–A). At the lower end of the vertical frame (11) a lower housing (12) is mounted which is formed by a closed chamber and in which one or more propellers (13) are fitted on a substantially horizontal propeller shaft. The propeller device (10) is provided with an electric motor (1) for turning the propeller device with respect to said vertical axis of rotation (A–A). A rotating part (2) of the electric motor producing the turning movement of the propeller device (10) is fixed directly to a turnable part (11, 14, 17) of the propeller device (10) and, similarly, a stationary part (3) of the electric motor is fixed to the fixed structure of the propeller device, ship, offshore structure or equivalent.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

Turnable propeller device for a ship, an offshore structure or equivalent

The invention relates to a turnable propeller device for a ship, an offshore structure or equivalent, which propeller device comprises a vertical frame which is mounted by means of bearings on a frame of the propeller device, ship or equivalent so as to be turnable with respect to a substantially vertical axis of rotation, and at the lower end of which vertical frame a lower housing is mounted which is formed by a closed chamber and in which one or more propellers are fitted on a substantially horizontal propeller shaft, in which connection the propeller device is provided with an electric motor for turning the propeller device with respect to said vertical axis of rotation.

The present invention relates in particular to the type of propeller devices which have previously been described, among other things, in *Finnish patent publications Nos. 65 589, 75 775, 79 991, 82 007 and 91 513* as well as in *Finnish patent applications Nos. 834441, 872690 and 945788*. The propeller devices described in these publications are of the type that they comprise a vertical frame mounted by means of bearings on the frame of a propeller device, a ship or equivalent so as to be turnable about a substantially vertical axis of rotation, at the lower end of which vertical frame a lower housing is mounted which supports one or more propellers revolving about a substantially horizontal shaft of rotation. The drive of the propellers may be arranged fully mechanically such that, from a power source provided in a ship or equivalent, drive power is transmitted from a drive shaft to an upper angle gear, which is fitted at the upper end of the vertical frame of the propeller device. From the upper angle gear, the drive power is further transmitted through a vertical shaft disposed within the vertical frame into a lower housing of the propeller device, and the drive power is transmitted through a lower angle gear provided in said lower housing to a substantially horizontal propeller shaft, and therefrom further to the propeller or propellers. For example, a diesel engine or a diesel-electric drive

machinery may be used as a power source. Hydraulically driven propeller devices are also prior known. At present, electric transmission is also used in which an electric motor is placed in the lower housing of a propeller device, said electric motor driving propellers directly or through a reduction gear. In respect of drive, an arrangement is also known in which an electric motor is placed in a ship or in a propeller device in a vertical position such that drive power is transmitted from the electric motor to a propeller shaft through an angle gear situated in a lower housing, so that no upper angle gear is required.

The propeller device has generally been made turnable such that the upper part of the vertical frame of the propeller device is supported on the frame of the propeller device, a ship or equivalent or on a fixed frame tube or a frame fitting member thereof by means of bearings. The turning movement of the propeller device has generally been provided such that a gear wheel is fitted to the turnable part of the propeller device coaxially with respect to the axis of rotation. Frequently, the gear wheel fitted to the turnable part of the propeller device is accomplished by means of a so-called rotation bearing, whose inner circumference incorporates gear teeth. The gear wheel is driven by means of one or more drive gear wheels which are in tooth contact with it. The drive gear wheel or the drive gear wheels are usually coupled to a planetary gear, to a secondary shaft of the planetary gear, and each planetary gear is most commonly driven by means of a hydraulic motor. The hydraulic motor in turn receives its drive power from a hydraulic power unit, whose pump is driven by an electric motor or by a drive shaft of the propeller device, for example, by means of belt transmission. An arrangement is also known in which a hydraulic motor drives a gear wheel fitted directly to a turnable part. In this arrangement, the size of the hydraulic motor becomes large and, hence, attempts are made to limit it by increasing the number of hydraulic motors. Arrangements are also known in which chain or belt transmission is used either totally or partly instead of gear transmission. In this kind of arrangements, information about the turning position of the propeller device is conveyed to a display unit generally electromechanically, in which connection a measurement detector receives its drive from a gear wheel fitted to a turnable part through mechanical transmission.

Since electric drives in ships are continuously increasing, the pump in a hydraulic power unit is also more and more often driven by an electric motor. Electric energy is thus converted in the electric motor first into mechanical energy, which is further converted in the pump into hydraulic energy. The hydraulic energy is transmitted by the power unit to a hydraulic motor where it is converted back into mechanical energy, and the low torque of the hydraulic motor is raised by means of mechanical transmission to a sufficiently high level in order that it should be able to turn the propeller device. The transmission ratio may be even over 500. In this kind of arrangement, the efficiency of the use of energy is not very good because of the mechanical transmissions and the conversions from one form of energy into another as well as because of the poor efficiency of hydraulic power transmission.

In prior art there are also known arrangements in which an electric steering gear is used for the steering of a propeller device. This differs from hydraulic steering in principle such that, instead of a hydraulic motor, a planetary gear is driven by means of a cage induction motor whose speed of rotation is regulated by an inverter. This steering arrangement thus also includes a mechanical transmission, which means that the solution hardly simplifies the structure of the propeller device at all. The benefit from the use of an electric steering gear as compared with hydraulic steering lies in that hydraulic power transmission has been omitted from between the electric motor and the planetary gear. This kind of electric steering also involves other problems, one source of them being a very high moment of inertia of the mass in the electric motor as compared with other parts of the power transmission line. For example, in possible cases of impact, the high moment of inertia of the mass in the rotor of the electric motor may damage the mechanical transmission, for the avoidance of which special arrangements are needed. Further, in this kind of arrangement, a brake is needed for holding the propeller device in place, and the service life of the brake must be designed for a very high number of engagement. An external load which is higher than the maximum steering moment may further result in the maximum speed of rotation of the planetary gear being clearly exceeded, which may lead to damage. All the above-mentioned problems in the known electric steering are due to the properties of the cage induction motor and to the mechanical transmission.

The objective of the present invention is to provide a substantial improvement over the known steering mechanisms of propeller devices. With a view to achieving this objective, the invention is mainly characterized in that a rotating part of an electric motor producing the turning movement of a propeller device is fixed directly to a turnable part of the propeller device and, similarly, a stationary part of the electric motor is fixed to the fixed structure of the propeller device, a ship, an offshore structure or equivalent.

The invention provides a number of significant advantages over the known arrangements, and of these advantages the following ones may be mentioned. A substantial advantage over both known hydraulic and electric steering systems is in that the structure of the steering system has been made considerably simpler than previously because no mechanical transmission is required. In the arrangement in accordance with the invention, information about the turning position of the propeller device is obtained directly from the turning motor, so that the mode of measurement of the present kind with its mechanical transmissions is not needed at all. Owing to the omission of these components, the structure of the frame of the upper part of the propeller device becomes considerably simpler. The omission of mechanical transmission reduces further the points of lubrication. Moreover, the efficiency of the use of energy improves as compared with the known arrangements because of the omission of mechanical transmission.

As compared with hydraulic steering in particular, the electric power required for steering in the invention is considerably smaller, because a substantial loss of power is caused in hydraulic steering because of the poor efficiency of hydraulic power transmission. A hydraulic power unit is a substantial source of noise, whereas the arrangement in accordance with the invention is almost noiseless. The conservation of space is substantial as compared with the present arrangements because the space required by the control unit of the electric motor is small and it can be placed more freely than a hydraulic power unit, which must be situated as close as possible to the propeller device. Since no hydraulic tubing or mechanical transmissions are needed, the thus saved space allows the components of a lubrication system to be mounted

on the frame of the upper part, in which connection no space need be reserved for a mechanical lubricator unit in a machine room, either.

In the arrangement in accordance with the invention, there is no need for cooling similar to that of the known arrangements. No separate cooling system is required, because heat is transferred into lubricating oil, which must be cooled in any event. There are fewer components and fewer possibilities of damage than previously and the need for maintenance is substantially smaller than in the known arrangements. The system in accordance with the invention is environmentally friendly, because in the arrangement in accordance with invention there are no problems associated with oil, characteristic of hydraulic steering, such as, oil leaks, replacement of filters, analysis of oil samples, oil changes, and treatment of waste oil. The steering system in accordance with the invention is suitable for use, for example, in diesel-driven, diesel-electrically driven and electrically driven propeller devices. In principle, the invention may be used whenever there is electric energy available. The other advantages and characteristic features of the invention come out from the following detailed description of the invention.

Next, the invention will be described by way of example with reference to the figures in the accompanying drawing.

Figure 1 is a schematic and partly sectional side view of a propeller device in accordance with a first embodiment of the invention.

Figure 2 shows a second embodiment of the invention as an illustration corresponding to that of Fig. 1.

Figures 3A to 3D schematically show further additional embodiments of the invention.

Figure 4 shows a further advantageous embodiment of the propeller device in accordance with the invention as an illustration corresponding to that of Fig. 1.

Fig. 1 of the drawing is thus a side view of a propeller device, which is generally denoted with the reference numeral 10. The propeller device 10 comprises a vertical frame 11, which is mounted on a frame 5 of the propeller device, a ship, an offshore structure or equivalent so as to be turnable about a substantially vertical axis of rotation A—A. A lower housing 12 formed by a closed chamber is mounted at the lower end of the vertical frame 11, in which housing a substantially horizontal propeller shaft (not shown) is mounted, propellers 13 being in turn mounted on the propeller shaft. The case shown in Fig. 1 relates to a twin-propeller structure, in which the propellers 13 are arranged to revolve in opposite directions of rotation. The turnable vertical frame 11 is supported on the frame 5 of the ship or equivalent and possibly additionally on a fixed frame tube or equivalent frame fitting member 6 by means of a support bearing 15 and a rotation bearing 16. The bearing arrangement is provided at the upper part of the vertical frame, i.e. in the region of a steering tube 14. The upper part of the vertical frame is supported on the rotation bearing 16 through a flange 17.

The steering, or turning, of the propeller device 10 with respect to the vertical axis A—A is accomplished in the invention, as shown in Fig. 1, by means of an electric motor 1. In the illustration of Fig. 1, the arrangement comprises the electric motor 1 which is large in diameter and whose cylindrical stator 3 is mounted on a fixed part, i.e. on the frame 5 of the ship or equivalent or on the fixed frame tube or equivalent frame fitting member 6 and, similarly, a cylindrical rotor 2 of the electric motor is fixed to a turnable part of the propeller device, i.e. in this case to the flange 17 of the upper part of the vertical frame, i.e. to the flange 17 of the steering tube. The rotor 2 may also be fixed directly to the steering tube 14. Thus, in the structure in accordance with the invention, the electric motor 1 constitutes a part of the structure of the propeller device 10. Further, in the construction in accordance with the invention, the electric motor 1 does not require a separate shaft, bearing means or frame structures, because they already exist and are available in the construction of the propeller device 10. Further, the arrangement in accordance with the invention does not need any mechanical gear between the electric motor 1 and the turnable part of the propeller device 10 for producing a turning movement.

The propeller device 20 shown in Fig. 2 differs to some extent from the structure of the propeller device shown in Fig. 1. In the illustration of Fig. 2, the propeller device 20 also comprises a vertical frame 21, which is mounted, in a manner corresponding to that of Fig. 1, on a frame of the propeller device, a ship, an offshore structure or equivalent so as to be turnable with respect to a substantially vertical axis of rotation A—A, which frame is denoted with the reference numeral 35 in Fig. 2. A lower housing 22 formed by a closed chamber is situated at the lower end of the vertical frame 21 and the lower housing 22 supports a propeller shaft on which a propeller or propellers 23 is/are mounted. Further, in the arrangement of Fig. 2, a lower angle gear (not shown) is placed in the lower housing 22, drive power being transmitted to said lower angle gear from a motor mounted in an upright position in the ship, advantageously from an electric motor 28 through a vertical drive shaft 29. Further, in the illustration of Fig. 2, the turnable vertical frame 21 of the propeller device is supported on the frame 35 of the ship or equivalent and possibly additionally on a fixed frame tube or equivalent frame fitting member 36 by means of a support bearing arrangement 25. In the illustration of Fig. 2, the support bearing arrangement 25 is arranged in the region of the upper part of the vertical frame, i.e. in the region of a steering tube 24.

In a manner similar to that of Fig. 1, in the illustration of Fig. 2, the steering, or turning, of the propeller device 20 with respect to the vertical axis A—A is also accomplished by means of an electric motor, which in Fig. 2 is denoted generally with the reference numeral 31. The electric motor 31 is in this embodiment, for example, a switched reluctance motor comprising an annular rotor 32, which is fixed to a turnable part of the propeller device 20, i.e. in the illustration of Fig. 2, to a flange 27 in the upper part of the vertical frame. A stator 33 of the electric motor 31 is bipartite in the illustration of Fig. 2 such that said parts of the stator 33 are situated in the axial direction of the axis of rotation A—A on both sides of the rotor 32. In the illustration of Fig. 2, the electric motor 31 may thus function as an electromagnetic trunnion bearing of the propeller device 20 carrying the weight of the propeller device. In that connection, the support bearings 25 of the propeller device may be merely radial bearings, which need not receive the weight of the

device. If something goes wrong with the electric system of the propeller device 20 in the structure shown in Fig. 2 such that the poles of the stator 33 of the electric motor 31 cannot be magnetized, the rotor 32 of the electric motor will descend on support of the stator 33, in which connection the friction between the stator 33 and the rotor 32 helps the turnable part of the propeller device to stay in place.

Figs. 3A and 3B show variants of the structure of the turning motor of the propeller device 10 shown in Fig. 1, in which structure the same principle is used as in the illustration of Fig. 2. In Fig. 3A, the turning motor, or the electric motor, of the propeller device is designated by the reference sign 1a. A stator 3a and a rotor 2a of the electric motor 1a are cylindrical, as also in the case of Fig. 1 such that the rotor 2a is fixed to the flange 17 of the turnable part of the propeller device and, similarly, the stator 3a is fixed to the fixed structure of the propeller device, a ship or equivalent. In order that the electric motor 1a shown in Fig. 3A might operate as an electromagnetic trunnion bearing for the propeller device in the manner shown in Fig. 2, a shoulder 7a is formed at the lower part of the stator 3a, which shoulder is directed inwards in the radial direction of the stator 3a and situated under the rotor 2a, the rotor 2a being able to be supported against said shoulder. This means that, in a disturbance situation of the electric system, the rotor 2a can descend on support of the shoulder 7a of the stator. A rotation bearing 16' may also serve in the case of Fig. 3A merely as a radial bearing in a manner similar to that of the support bearing 15.

The arrangement of Fig. 3B corresponds to that of the illustration of Fig. 3A in other respects except that the arrangement of a stator 3b and a rotor 2b of the electric motor 1b is opposite to the illustration of Fig. 3A. The rotor 2b is still fixed to the turnable part of the propeller device and the stator 3b is fixed to the fixed structure of the propeller device, ship or equivalent. In the illustration of Fig. 3B, a support flange 8b extending over the stator 3b is formed at the upper edge of the rotor 2b, which flange is directed outwards in the radial direction of the rotor. In that connection, when there occurs a disturbance situation in the electric system, said

support flange 8b of the rotor descends on support of the stator 3b. The operation thus corresponds to that shown and described in Figs. 2 and 3A.

Figs. 3C and 3D are further variants of the structure of the electric motor shown in Fig. 1. In the case of Fig. 3C, an electric motor is denoted with the reference sign 1c. A rotor 2c is fixed to the flange 17 of the turnable part of the propeller device in a manner corresponding to that of Fig. 1, but in respect of a stator the structure differs from that shown in Fig. 1 in that, in the case of Fig. 3C, the stator is bipartite comprising stator rings 3c,3c' disposed coaxially one within the other, the cylindrical rotor 2c being disposed between the stator ring. For suspending the inner stator ring 3c', a "shelf" 9c is mounted onto the fixed structure of the propeller device, ship or equivalent, on which shelf the inner stator ring 3c' is supported. In the illustration of Fig. 3C, the support bearing 15 and the rotation bearing 16' of the propeller device function in the manner described in Fig. 1.

In the case of Fig. 3D, an electric motor 1d corresponding to the illustration of Fig. 3C also functions as an electromagnetic trunnion bearing of the propeller device. In that case, a connecting portion 7d situated under a rotor 2d connects stator rings 3d, 3d' disposed coaxially one within the other as in the illustration of Fig. 3d. This means that, in a disturbance situation of the electric system, the rotor 2d can descend totally on support of the connecting portion 7d connecting the stator rings of the electric motor 1d.

The constructions described above in which the electric motor is arranged to operate as the electromagnetic trunnion bearing of the propeller device, may be improved further such that said electric motor operates as a perfect bearing. In that connection, the electric motor receives both radial and axial forces as well as a tilting moment. Thus, the bearing arrangement of the propeller device can be taken care of solely by means of said electric motor, so that other bearings are not necessarily even needed.

In Fig. 4 of the drawing, a propeller device is denoted with the reference numeral 40. The propeller device 40 comprises, for example, in a manner corresponding to

that of Fig. 1, a vertical frame 41, which is mounted on a frame 55 of the propeller device, a ship, an offshore structure or equivalent so as to be turnable about a substantially vertical axis of rotation A—A. A lower housing 42 formed by a closed chamber is mounted at the lower end of the vertical frame 41, in which housing a substantially horizontal propeller shaft (not shown) is mounted, propellers 43 being in turn mounted on the propeller shaft. Like Fig. 1, Fig. 4 also relates to a twin-propeller structure, in which the propellers 43 are arranged to revolve in opposite directions of rotation. The turnable vertical frame 41 is supported on the frame 55 of the ship or equivalent and possibly additionally on a fixed frame tube or equivalent frame fitting member 56 by means of a support bearing 45 and a rotation bearing 46. The bearing arrangement is provided at the upper part of the vertical frame, i.e. in the region of a steering tube 44.

The steering, or turning, of the propeller device 40 with respect to the vertical axis A—A is accomplished in the invention, as shown in Fig. 4, by means of an electric motor 51. In the illustration of Fig. 4, the electric motor is advantageously a permanent magnet synchronous machine, and the motor arrangement comprises a large-diameter, cylindrical stator 53, which is mounted on a fixed part, i.e. on the frame 55 of the ship or equivalent or on the fixed frame tube or equivalent frame fitting member 56. A rotor 52 is in the embodiment of Fig. 4 also fixed to a turnable part of the propeller device, i.e. to an upper part of the vertical frame, that is, directly to the steering tube 44. Thus, the rotor 52 constitutes a part of the structure of the propeller device 40. In the case of a permanent magnet synchronous machine, the rotor in its entirety can be manufactured as a massive construction, for example, of cast steel, in which connection the rotor can in itself function as a part of the load-bearing structure of the turnable part of the propeller device 40. In that case, the frame part of the rotor can operate as the steering tube 44 and the permanent magnets of the rotor 52 can be attached to its surface or into cavities machined in its surface. In the case of a permanent magnet synchronous machine, the rotor may also be accomplished as a cylindrical structure, for instance, in the manner shown in Figs. 1, 3a, 3b, 3c, 3d, or as an annular body, as shown in Fig.2. In that connec-

tion, the permanent magnets would be attached to the surface of the cylindrical or annular body or into cavities machined in the surface of the body.

In the application in accordance with the invention, it is possible to contemplate using any electric motor that can be controlled so as to rotate at very low speeds of rotation and which can generate a high torque at these low speeds of rotation. However, of the existing types of electric motor, the permanent magnet synchronous machine described above or a switched reluctance motor (SR motor, Switched Reluctance Motor in English) can best be contemplated being applied to the purpose in accordance with the invention, because on these no winding is needed for the magnetizing of the rotor, and thus no electric current need be conducted to the turnable part of the propeller device. The properties (low speed of rotation, regulation of the speed of rotation, directional accuracy, and holding in place) required of the steering of the propeller device make it necessary to use a controlled power source, i.e. an inverter, in the control of the electric motor.

By calculation, it may be shown that the torque obtained by the motor, whether it is a permanent magnet synchronous machine or a switched reluctance motor (SR motor), is sufficient to steer the propeller device, and that the motor may be accommodated inside the propeller device without considerable constructional changes. It is worth optimizing the construction of the propeller device considering the possibilities offered by the invention. The length of the rotor may be further shortened to almost one half by a construction in which the rotor is arranged to rotate between two stator rings.

In the assurance of the steering system, the question is mainly whether some parts of the steering system must be doubled. There is no need to double the rotor, because it has no winding and, thus, there is no possibility of it being broken. In the stator, it is mainly only the windings that may be damaged. The likelihood of damage is, however, very small, and if several phases are used, a fault in one phase does not necessarily mean a total loss of steerability. In the case of a switched reluctance motor, the propeller device can be locked electromagnetically in place by

magnetizing a sufficient number of poles by an external current, although the inverter would have been broken. Consequently, there is no absolute need for a mechanical holding-in-place brake, which could be in diameter, for example, a large band or disk brake, although this would be even required by standards and regulations relating to shipping and ships.

Above, the invention has been described by way of example with reference to the figures of the accompanying drawing. However, the invention is not confined solely to the examples shown in the figures, but the various alternative embodiments of the invention may vary within the inventive idea defined in the accompanying claims.

Claims

1. A turnable propeller device for a ship, an offshore structure or equivalent, which propeller device comprises a vertical frame (11;21;41) which is mounted by means of bearings on a frame (5;35;55) of the propeller device, ship or equivalent so as to be turnable with respect to a substantially vertical axis of rotation (A—A), and at the lower end of which vertical frame (11;21;41) a lower housing (12;22;42) is mounted which is formed by a closed chamber and in which one or more propellers (13;23;43) are fitted on a substantially horizontal propeller shaft, in which connection the propeller device (10;20;40) is provided with an electric motor (1;1a,1b,1c,1d;31;51) for turning the propeller device with respect to said vertical axis of rotation (A—A), **characterized** in that a rotating part, a rotor (2;2a,2b,2c,2d;32;52) of the electric motor producing the turning movement of the propeller device (10;20;40) is fixed directly to a turnable part (11,14,17;21,24,27;41,44) of the propeller device (10; 20; 40) and, similarly, a stationary part, a stator (3;3a,3b,3c,3d;33;53) of the electric motor is fixed to the fixed structure of the propeller device, ship, offshore structure or equivalent.

2. A propeller device according to claim 1, **characterized** in that the rotor (2) of the electric motor is fixed directly to the upper part of the vertical frame of the propeller device or to an equivalent steering tube (14) or to a flange (17) situated at the upper part of the vertical frame, through which flange the propeller device (10) is supported on a rotation bearing (16).

3. A propeller device according to claim 1, **characterized** in that the rotor (52) of the electric motor is formed as a massive construction and arranged to operate as a part of the load-bearing structure of the turnable part (41,44) of the propeller device (40).

4. A propeller device according to claim 1 or 2, **characterized** in that the rotor (2; 2a,2b,2c,2d) of the electric motor (1;1a,1b,1c,1d) intended for turning of the

propeller device is a cylindrical member fixed to the turnable part of the propeller device.

5. A propeller device according to claim 4, **characterized** in that the stator (3) of the electric motor (1;1a,1b,1c,1d) intended for turning of the propeller device is formed of two cylindrical stator rings (3c,3c';3d,3d') disposed coaxially one inside the other, the cylindrical rotor (2c,2d) being disposed between said stator rings.

6. A propeller device according to claim 1 or 2, **characterized** in that the rotor (32) and the stator (33) of the electric motor are annular members situated one upon the other in the direction of the axis of rotation (A—A).

7. A propeller device according to claim 6, **characterized** in that the stator (33) comprises two stator rings placed one upon the other in the axial direction, the annular rotor (32) being disposed between said stator rings.

8. A propeller device according to any one of the preceding claims, **characterized** in that the electric motor (1;1a,1b,1c,1d;31;51) is a permanent magnet synchronous machine.

9. A propeller device according to claim 8, **characterized** in that the permanent magnets of the rotor (2;2a,2b,2c,2d;32;52) of the electric motor are attached to the surface of the turnable part (41,44) or the cylindrical (2;2a,2b,2c,2d) or the annular (32) member of the propeller device (10;20;40) or into cavities machined in its surface.

10. A propeller device according to any one of claims 1 to 7, **characterized** in that the electric motor (1;1a,1b,1c,1d;31) is a switched reluctance motor.

11. A propeller device according to any one of the preceding claims, **characterized** in that the electric motor (1;1a,1b,1c,1d;31;51) is provided with a controlled power source, i.e. an inverter.

12. A propeller device according to any one of the preceding claims, **characterized** in that the electric motor is arranged to operate as an electromagnetic trunnion bearing of the turnable part of the propeller device and to receive the load in the direction of the axis of rotation (A—A).

13. A propeller device according to any one of claims 1 to 11, **characterized** in that the electric motor is arranged to operate as the only bearing of the turnable part of the propeller device and to receive all the loads acting on the turnable part.

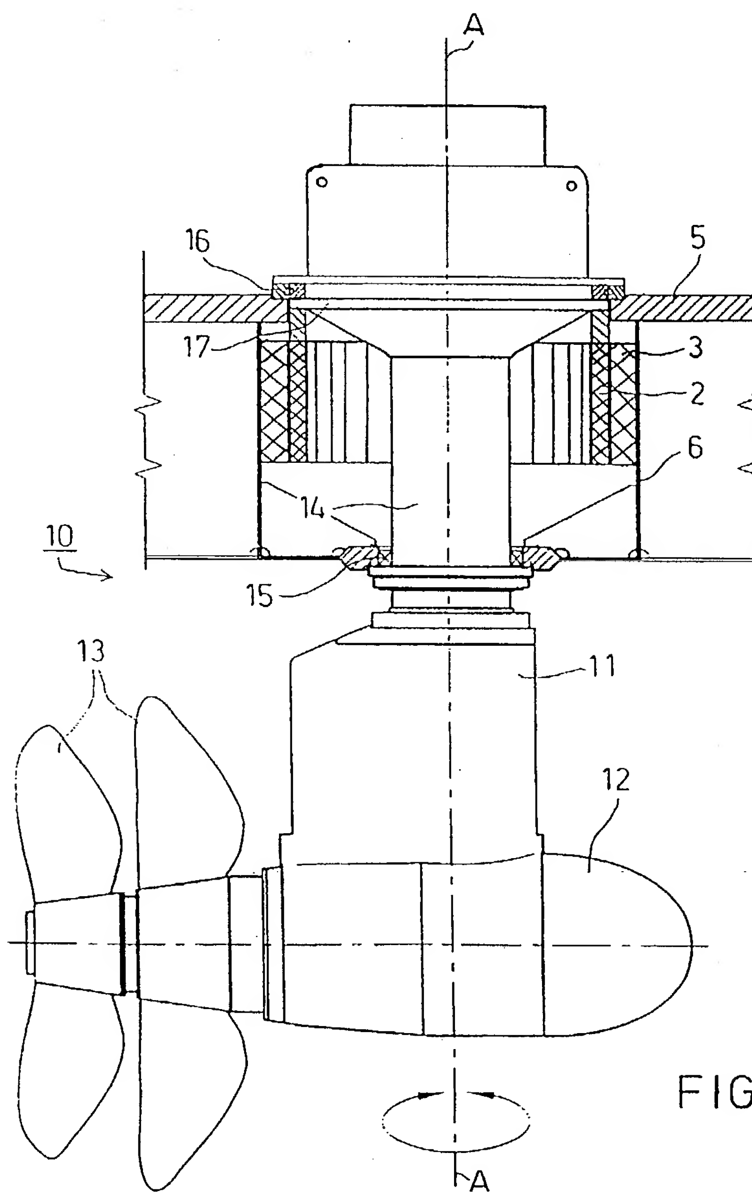


FIG. 1

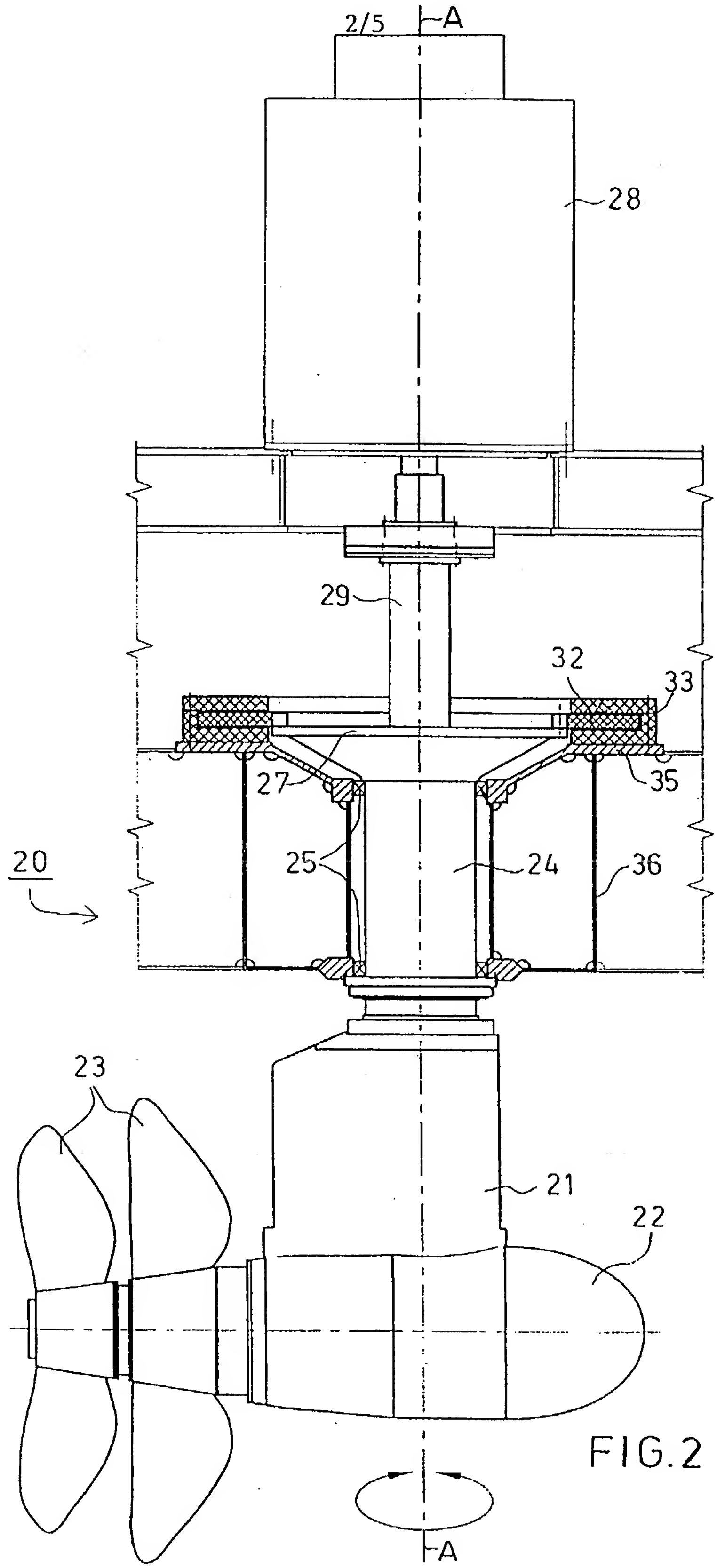


FIG. 2

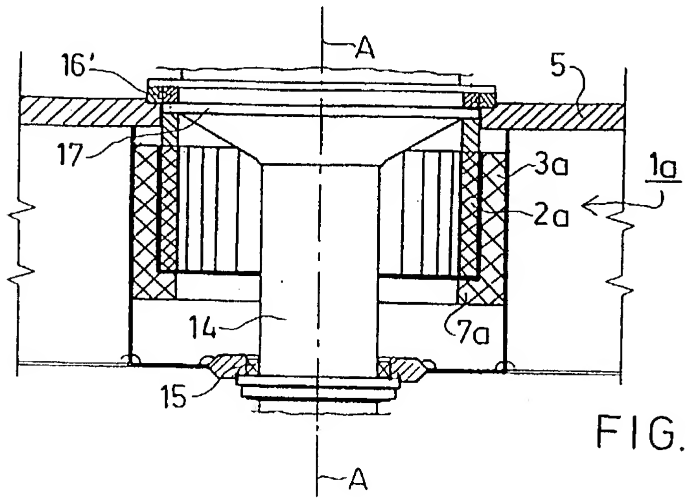


FIG. 3A

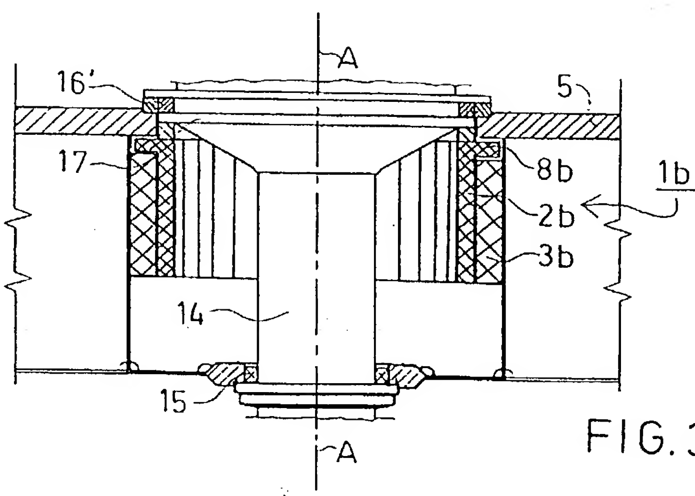


FIG. 3B

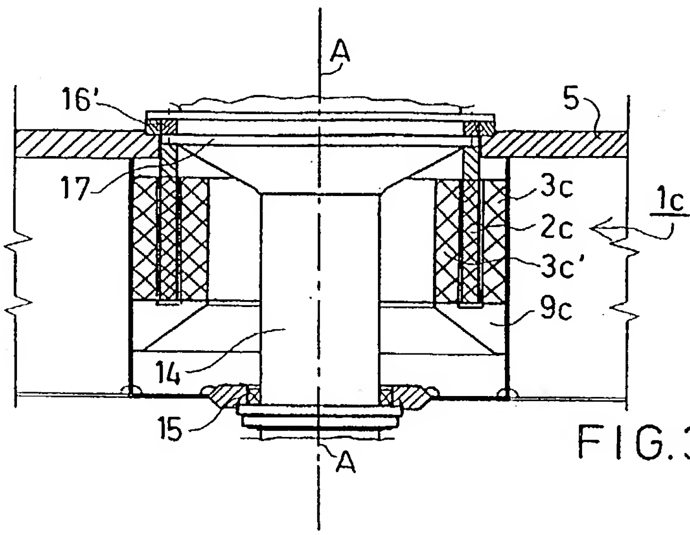


FIG.3C

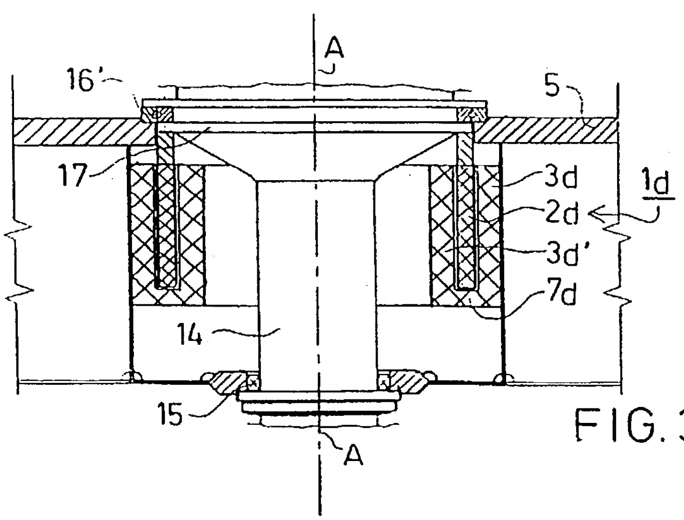


FIG. 3D

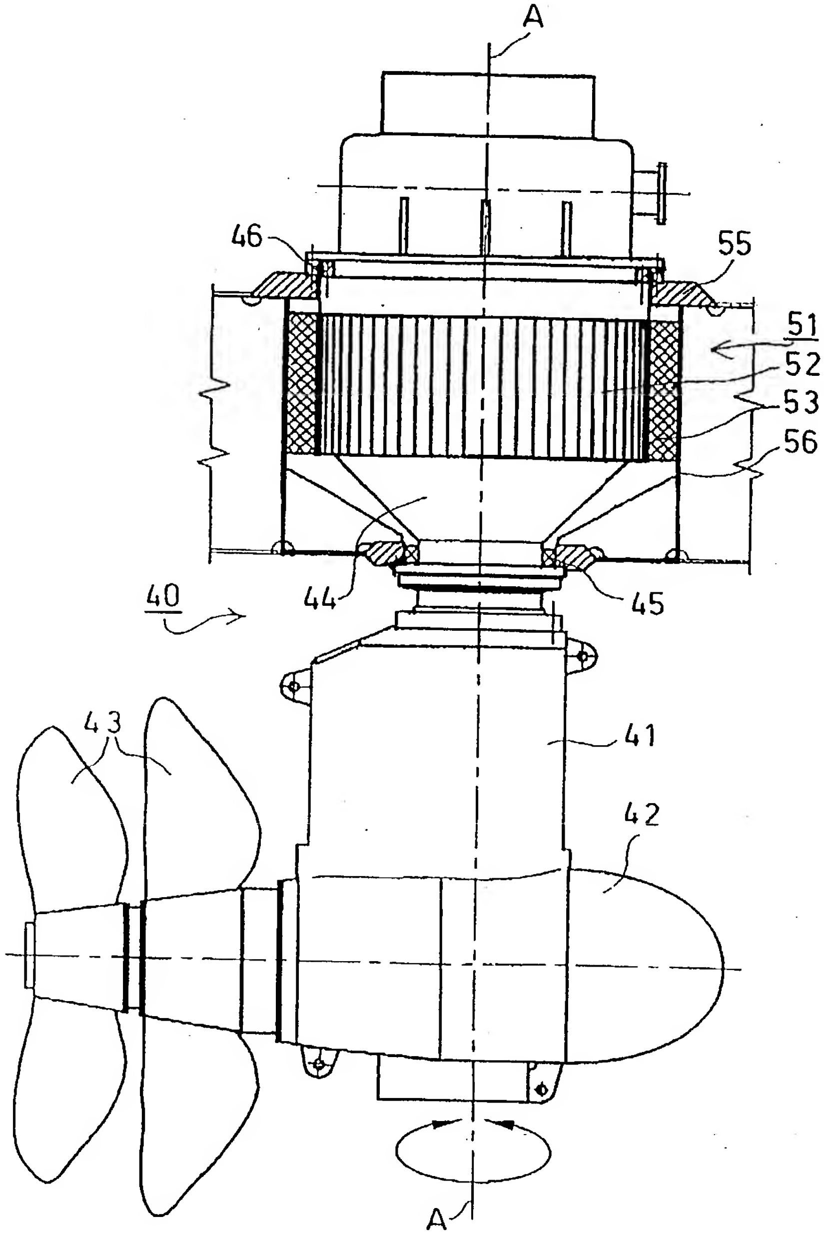


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/01061

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B63H 20/12, B63H 21/17, B63H 25/42

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B63H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5403216 A (SALMI ET AL.), 4 April 1995 (04.04.95), column 6, line 9 - line 20, figure 3, abstract --	1-13
A	EP 0035600 A1 (MACHINEFABRIEK EN REPARATIEBEDRIJF LIPS-KELLER B.V.), 16 Sept 1981 (16.09.81), page 6, line 30 - page 7, line 3, figure 3, abstract --	1-13
A	US 5108322 A (HENDERSON), 28 April 1992 (28.04.92), column 4, line 26 - line 57, figures 3,4, abstract --	1-13

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention.
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 April 2000	02 May 2000 (02.05.00)

Name and mailing address of the ISA	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Björn Salén/AB Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/01061

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2336297 A1 (ATELIERS DE CONSTRUCTIONS ELECTRIQUES DE CHARLEROI), 22 July 1977 (22.07.77), page 2, line 14 - line 18, figures 1,2 -- --------	1-13

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI 99/01061

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5403216 A	04/04/95	CA 2107202 A	29/03/94
		DE 69302348 D,T	26/09/96
		DK 590867 T	12/08/96
		EP 0590867 A,B	06/04/94
		SE 0590867 T3	
		ES 2087662 T	16/07/96
		FI 96590 B	15/04/96
		FI 924334 A	29/03/94
		JP 6191484 A	12/07/94
		NO 933441 A	29/03/94
		RU 2097266 C	27/11/97
		SG 43165 A	17/10/97
EP 0035600 A1	16/09/81	NONE	
US 5108322 A	28/04/92	NONE	
FR 2336297 A1	22/07/77	NONE	